MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1 , 2019/2020

ERT3026 – AUTOMATION
(RE)

17 OCTOBER 2019
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of **7 pages** including cover page and Appendix with **4 Questions** only.
2. Attempt **ALL** questions. The distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Design a programmable logic controller (PLC) ladder diagram to control an apple packing line control system to satisfy the following conditions: -

- When press the start push button, red light starts blinking.
- And then after a delay of 60 seconds, the box conveyor begins moving.
- Upon detection of a box presents, the box conveyor stops and apple conveyor begins moving.
- The sensor will count for 10 apples. The apples conveyor stops and the box conveyor move again.
- Counter will be auto reset and operation repeats until stop push button is pressed.
- When press the stop push button, red light stop blinking and green light will start blinking.

[20 marks]

(b) Construct the ladder logic diagram for the following Boolean Logic equations:

(i) $Y = (X1 \cdot X2) + X3$ **[2 marks]**

(ii) $Y = (X1 + X2) \cdot \overline{X3} \cdot \overline{X4}$ **[3 marks]**

Where X1, X2, X3, X4 are inputs and Y is the output.

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Question 2

(a) An **eight-station** rotary indexing machine performs the machining operations as shown in the **Table Q2(a).** The transfer time for the machine is **0.15 min per cycle**. A study of the system was undertaken, during which time **2000 parts** were completed. It was determined in this study that when breakdown occur, it takes an average of **7.0 min** to make repairs and get the system operating again. For this study period, determine:

(i) Average actual production rate. **[12 marks]**

(ii) Line uptime efficiency. **[3 marks]**

(iii) Require time to produce the 2000 parts. **[3 marks]**

Table Q2(a) Eight-station Machining Operations

Station	Process	Process time(min)	Breakdowns
1	Load part	0.50	1
2	Mill top	0.85	47
3	Mill sides	1.10	82
4	Drill two holes	0.60	8
5	Ream two holes	0.43	31
6	Drill six holes	0.92	58
7	Tap six holes	0.75	22
8	Unload part	0.40	1

(b) A certain part is routed through **six machines** in a batch production plant. The setup and operation times for each machine are given in the **Table Q2 (b)**. The batch size is **100** and the average nonoperation time per machine is **12 hours**. Determine manufacturing lead time.

[7 marks]

Table Q2 (b) The Setup and Operation Times

Machine	Setup time (hr)	Operation time (min)
1	2	3.5
2	4	5.0
3	8	10.0
4	4	2.5
5	3	4.1
6	3	1.9

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Question 3

(a) A **300 ft** long roller conveyor, which operates at a velocity of **80 ft/min**, is used to move pallets between load and unload stations. Each pallet carries **12 parts.** Cycle time to load a pallet is **15.0 sec** and one worker at the load station is able to load pallets at the rate of **4 per min**. It takes **12.0 sec** to unload at the unload station. Determine:

(i) The number of pallets on the conveyor at one time. **[6 marks]**

(ii) Hourly flow rate of parts. **[3 marks]**

(b) The **Table Q3 (b)** defines the precedence relationships and element times for a new model toy.

(i) If the ideal cycle time is **20.0 min**, repositioning time is **2.0 min**, and uptime proportion is assumed to be **1.0**, what is the theoretical minimum number of workstations required to minimize the balance delay under the assumption that there will be one worker per station?

[7 Marks]

(ii) Assign the work elements to each station and find balance delay.

[9 Marks]

Table Q3(b): The Precedence Relationships and Element Times

Work element	T_e (min)	Immediate predecessors
1	11	-
2	3	1
3	4	2
4	6	2
5	6	2
6	8	2
7	3	3,4
8	5	5
9	7	7
10	6	6,8
11	4	9,10
12	13	11

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Question 4

A semi-automated flexible manufacturing system is used to produce three products. The products are made by two automated processing stations followed by an assembly station. There is also a load/unload station. Material handling between stations in the FMS is accomplished by mechanized carts that move tote bins containing the particular components to be processed and then assembled into a given product. The carts transfer tote bins between stations. In this way the carts are kept busy while the tote bins are queued in front of the workstations. Each tote bin remains with the product throughout processing and assembly. The details of the system can be summarized as shown in the **Table Q4.1**:

Table Q4.1 FMS Summarize

Station	Description	Number of servers
1	Load and unload	2 human workers
2	Process X	1 automated server
3	Process Y	1 automated server
4	Assembly	2 human workers
5	Transport	***Number of carriers to be determined.***

The product mix fractions and station processing times for the parts are presented in the **Table Q4.2**. The same station sequence is followed by all products: 1→2 →3 →4 →1. The average cart transfer time between stations is **4.0 min**.

Table Q4.2 The Product Mix Fractions and Station Processing Times

Product j	Product mix p_j	Station 1	Station 2	Station 3	Station 4	Station 1
A	0.35	3 min	9 min	7 min	5 min	2 min
B	0.25	3 min	5 min	8 min	5 min	2 min
C	0.40	3 min	4 min	6 min	8 min	2 min

(a) What is the bottleneck station in the system, assuming that the material handling system is not the bottleneck? **[10 marks]**

(b) At full capacity, what are the overall production rate of the system and the production rate for each product? **[7 marks]**

(c) What is the minimum number of carts in the material handling system required to keep up with the production workstations? **[2 marks]**

(d) Compute the utilization of each system. **[6 marks]**

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APPENDIX

TABLE 1: Some Useful Formulas

$R_p = \dfrac{1}{T_p}$	$T_c = T_m + T_s$	$T_c = \dfrac{s_p}{v_c}$		$T_t = \dfrac{L_s}{v_c}$
$WL = \dfrac{Q\ T_c}{1-q}$	$n = \dfrac{WL}{AT}$	$n = \dfrac{w}{M}$		$AT = S_w H_{sh} AU$
$T_c \leq \dfrac{E}{R_p}$	$E_b = \dfrac{T_{wc}}{n\ T_s}$	$f_p = \dfrac{v_c}{s_p}$	$T_c = Max\{T_m, T_s\} + T_r$	
$D = \dfrac{FT_d}{T_p}$	$E = \dfrac{T_c}{T_p}$	$T_s = MaxT_{si} \leq T_{mc} - T_r$		
$T_C = T_L + \dfrac{L_d}{v_c} + T_U + \dfrac{L_e}{v_e}$		$T_p = T_c + FT_d$		
$F = \sum_{i}^{n} p_i$		$F = 1 - \left[\prod_{i=1}^{n}(1-p_i)\right]$		
$T_{wc} = \sum_{j=1}^{n_e} T_{ej} = \sum_{i}^{n} T_{si}$		$d = \dfrac{nT_s - T_{wc}}{nT_s}$		
$WL_i = \sum_{j}\sum_{k} t_{ijk}\ f_{ijk}\ p_j$		$n_t = \left(\sum_{i}\sum_{j}\sum_{k} f_{ijk}\ p_j\right) - 1$		
$WL_{n+1} = n_t t_{n+1}$		$BS_i = WL_i(R_p^*)$		
$R_p^* = \dfrac{s^*}{WL^*}$		$R_{pj}^* = p_j(R_p^*)$		
$U_i = \dfrac{WL_i}{s_i}(R_p^*)$		$\overline{U} = \dfrac{\sum_{i+1}^{n+1} U_i}{n+1}$		$\overline{U_s} = \dfrac{\sum_{i+1}^{n+1} s_i U_i}{\sum_{i=1}^{n} s_i}$
$N^* = R_p^*\left(\sum_{i=1}^{n} WL_i + WL_{n+1}\right)$				

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TABLE 2: Extended Bottleneck Model

Case 1: N < N*	Case 2: N ≥N*
$MLT_1 = \sum_{i=1}^{n} WL_i + WL_{n+1}$	$R_p^* = \frac{s^*}{WL^*}$
$R_p = \frac{N}{MLT_1}$	$R_{pj}^* = p_j\left(R_p^*\right)$
$R_{pj} = p_j R_p$	$MLT_2 = \frac{N}{R_p^*}$
$T_w = 0$	$T_w = MLT_2 - \sum_{i=1}^{n} WL_i + WL_{n+1}$

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